University of Edinburgh

Founded in 1583
One of the largest and oldest Universities in Britain
Over 22000 students, 3300 academics and 3000 support staff
60% of all 5* top-rated researchers in Scotland
25% of Scotland’s total HE research income
There are three Colleges – including Science and Engineering
Located here in KB campus
35% of university staff and students
Larger than most Scottish universities
There are seven Schools including Engineering
School of Engineering

Teaching
   – c280 Graduates/annum

Research
   – C50 PhDs/annum (180 postgraduate students)
   – 1302 Journal papers 2001-7
   – 1521 Conference papers 2001-7
   – 114 Invited Keynote/Plenary papers 2001-7
   – 21 paper prize awards in 2006-7
   – 5 academics on fellowship/industrial support

Knowledge Transfer
   – 14 recent spin-out and start-up companies
   – 60 patents awards and PCT filings since 2001
3rd in the UK, 1st in Scotland

- Research Fortnight analysis for UoA25: Engineering
  - quality and quantity of research
- University Numbers “Power”
- 1 Cambridge 150.0 1.00
- 2 Oxford 85.4 0.49
- 3 Edinburgh 87.4 0.39
- 4 Imperial 67.7 0.36
- 5 Warwick 69.5 0.35
- 6 Heriot-Watt 73.3 0.33

55% world-leading/internationally excellent
- all internationally recognised

There are five Research Institutes including Energy Systems
Academic Staff

Institute for Energy Systems
Prof A. R. Wallace
Prof I. G. Bryden
Prof J. W. Bialek
Prof R. J. Barthelmie
Prof S. H. Salter (Emeritus)
Reader Dr D. M. Ingram
Dr T. Bruce
Dr S. Djokic
Dr D.E. Macpherson
Dr V. Venugopal
Dr J. P. Chick
Dr G. P. Harrison
Dr M.A. Mueller
Dr D. Mignon
Dr C. L. Pritchard (Fellow)

Energy Academy
Prof B. Richards
Prof J. Side
Prof B. Tohidi
Prof P. Zelenay
Prof J. I. B. Wilson
Reader Dr S. Tao
Dr S. Kerr
Dr R.E. Harris
Dr W. Früh
Dr P. Kew
Dr D. McNeil
Dr B.T. Linfoot
Dr E. Owens
Dr T. Mallick
Dr M. Dunnigan

Energy
Edinburgh Research Partnership in Engineering and Mathematics
Research Staff

Mr J. Taylor
Dr M. Winskel
Mr H. Jeffrey
Dr G. Payne
Dr S. Couch
Dr A. McDonald
Dr N. Ochoa
Dr C. Dent
Dr R. Barik
Dr T. Davey
Dr D. Forehand
Mr. O. Keysan
Mr. N. Hodgins
Dr N. Markusson
Ms B. Morhan
Mr J. Porro
Mr B. Sellar
Dr. J Shek
Mr Z. Song

PhD Students: 40

Dr D. Jenkins
Dr M. Bowen
Mr A. Peacock
Dr B. Rowan
Dr Y. Jiang
Dr G. Kocher
Ms S. Turan
Mr C. Bullen
Ms G. Wood
Mr P. Pallawella
Dr R. Lan

PhD Students: 30
Research Activities

**Marine Energy and Coastal Defence**
Wallace, Bryden, Salter, Ingram, Bruce, Venugopal, Side, Kerr, Harris, McNeil, Linfoot, Owens, Wilson

**Renewable Energy and Climate**
Harrison, Chick, Fruh,

**Energy Conversion and Network Delivery**
Bialek, Mueller, Djokic, Macpherson, Dunnigan

**Fuel Cells and Energy Storage**
Mignard, Pritchard, Tohidi, Zelany, Tao, Newborough,

**Photovoltaics and Solar Energy**
Richards, Mallick

**Urban Energy Demand and Supply**
Kew, McNeil
Alignment along RE Supply Chain

Wave statistics and characterisation
Tidal current resource assessment
Wind and atmospheric modelling
Renewable resource assessment
Climate impacts analysis
Coastal defence

Advanced numerical modelling
Physical modelling
Evolutionary computing
Fluid power conversion
Novel electrical machines
Power electronic interfaces
Network integration
Power quality
Congestion management
PS Dynamics and stability
Lifecycle analysis
Energy economics and policy

Energy
Edinburgh Research Partnership in Engineering and Mathematics
Some original and highly inventive work was carried out in Edinburgh’s wave tank in the 1970s.
Until now
Start-ups and Spin-outs

Pelamis Wave Power – formerly OPD

Renewable Devices

Artemis Intelligent Power

Edinburgh Designs

Energy
Edinburgh Research Partnership in Engineering and Mathematics
Facilities – Wave & current tanks
Facilities – Machine Test Labs
Current/Recent Awards

EPSRC SuperGen Marine Energy Phases 1 & 2
FP7 EQUIMAR
NERC Scottish Lobe of UK Energy Research Centre
EPSRC SuperGen FutureNet 1 and FlexNet 2
EPSRC AURA-NMS Strategic Industry Partnership
EPSRC AMPERES Network Asset Management
EPSRC PV-21 Solar Photovoltaic
DTI MRDF Test Protocols
SEexec, SE and other PoC and KT awards in marine
PISCES from DFID Energy Access in Africa
The SuperGen Marine Energy Research Consortium

Phase 2  Oct 2007 – Sep 2011
Aims and objectives

EPSRC-funded 4 year collaborative project from Oct 2008-Sep 2011 now at end of year 1

Generic research continuing to support emerging industry with aims and objectives to:

1. Increase knowledge and understanding of device-sea interactions of energy converters from model-scale in the laboratory to full size in the open sea.
2. Build capacity in and for the sector
3. Internationalise effort and collaboration
Aims and objectives
Academic engagement

Core partners
University of Edinburgh
Queen’s University Belfast
Heriot Watt University
Lancaster University
University of Strathclyde

Affiliate partners
University of Durham
Southampton University
The Robert Gordon University
University of Manchester
University of Exeter
UHI Millennium Institute

Overseas partners
HMRC Cork, TU – Delft, ECN - Nantes
Dalhousie University - Canada
Oregon State University, Florida Atlantic University, UMass – USA
Universities of Osaka City and Hokkaido – Japan
Harbin Engineering University, Guangzhou Institute for Energy Conversion (CAS) and Dalian University of Technology - China
Industrial engagement

Research Advisory Forum formed to include:

Marine Current Turbines, Open Hydro,
Pelamis Wave Power, Ocean Power Technology,
Scottish&Southern Energy, Scottish Power, EdF, E-On, NPower
ETI, Carbon Trust,
EMEC, NaREC,
Crown Estates, Scottish Natural Heritage

Also continuing and new collaborations in specific aspects of research
# Workstreams and staff map

<table>
<thead>
<tr>
<th>Workstream (WS)</th>
<th>Description</th>
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<tr>
<td>WS1</td>
<td>Numerical and physical convergence</td>
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<tr>
<td>WS2</td>
<td>Optimisation of collector form and response</td>
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<tr>
<td>WS3</td>
<td>Combined wave and tidal effects</td>
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<td>WS4</td>
<td>Arrays, wakes and near field effects</td>
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<td>WS5</td>
<td>Power take-off and conditioning</td>
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<td>WS6</td>
<td>Moorings and positioning</td>
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<td>WS7</td>
<td>Advanced control and network integration</td>
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<tr>
<td>WS8</td>
<td>Reliability</td>
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<tr>
<td>WS9</td>
<td>Economic analysis of variability and penetration</td>
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<tr>
<td>WS10</td>
<td>Ecological Consequences of Tidal &amp; Wave Energy Conversion</td>
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<tr>
<td>WS11</td>
<td>Doctoral Training Programme</td>
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<tr>
<td>WS12</td>
<td>Inreach, dissemination and outreach</td>
</tr>
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</table>
WS1: Numerical and physical convergence

• A systematic study of the applicability of alternative analytic strategies for wave and tidal current systems

• This includes:
  – Identification and benchmarking of tank test procedures and techniques between different tanks
  – Identification and benchmarking of alternative numerical analysis techniques
  – Cross comparison and systematic evolution of best practise in both
WS1: Numerical and physical convergence
WS1: Numerical & physical convergence

New surface measuring techniques are showing early promise
WS2: Optimisation of collector form

Genetic algorithms, numerical modelling and tank testing is being used to evolve better, maybe ultimately even optimal, designs of wave energy converters.
WS3: Combined wave and tidal effects

• Research is being conducted into:
  – the influence of waves on the effective operation and design of tidal current systems
  – the influence of currents on the effective operation and design of wave energy systems

• Tests tanks are being modified, numerical models developed and customised and field facilities commissioned!
WS3: Combined wave and tidal effects

This work is advancing design, prediction and test procedures to recognise combined presence and effects of wave and tidal currents.

Tests are being conducted at Queens, Edinburgh and in a new dedicated 1/10th scale facility at Portaferry and at EMEC.
WS4: Arrays, wakes and near field effects

- Looking towards commercial deployment!
  - Deploying devices for optimal operation in arrays
  - Developing guidelines for devices designed for optimal array operation.
  - Assessing cumulative impacts.

- Once again, the work is numerical, laboratory and field based
WS5: Power take-off and conditioning

The prime-mover, drive-train, generator and power converter must be designed from the outset in an integrated manner, fit for the purpose in the working environment. This work is integrating structural, magnetic, thermal and electrical designs to optimise performance:cost ratio.
WS6: Moorings and positioning

This work is establishing design methods for the safe, economic station keeping of arrays taking account of short and long term loading in combined wave, current and winds to predict coupled response from combined device and mooring loads.
WS7: Advanced control/network integration

This work is developing continuously adapting control techniques to optimise energy extraction and survivability. Interaction of arrays of devices with actively controlled distribution networks to assess impact and integration.
WS8: Reliability

This work will establish an effective method to quantify the reliability of marine energy converters even in the scarcity of industry-specific component failure rates and environmental data. It will explore the effect of changing maintenance strategy on availability in arrays.
WS9: Economic analysis of variability

This work is predicting the pattern and timing of future uptake of marine energy by the market, recognising its nature and location recognising the variability of generation and peripherality of sites - and the sensitivities of these to changing economic conditions
WS 10: Ecological Consequences of Marine Energy Conversion*

- What are the principal ecological consequences of the extraction of tidal and wave energy in coastal and more offshore zones?
- To what extent can such changes be predicted from forecasts of change in the ambient flow field, energy and associated particulate regimes?
- To what extent are these observable in the field and amenable to compliance monitoring for statutory purposes?
Capacity Building
Doctoral Training Programme

Aim: To re-vitalise the supply of trained scientists and engineers for the academic, industrial and infrastructure sectors of marine energy.

*It operates across core and affiliate universities.*
## Workshop Programme

<table>
<thead>
<tr>
<th>Month</th>
<th>Topic</th>
<th>Venue</th>
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</thead>
<tbody>
<tr>
<td>Feb 2008</td>
<td>Wave Hydrodynamics</td>
<td>Edinburgh</td>
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<tr>
<td>Jun 2008</td>
<td>Marine Ecology and Field world</td>
<td>Orkney</td>
</tr>
<tr>
<td>Sep 2008</td>
<td>Economics</td>
<td>Glasgow</td>
</tr>
<tr>
<td>Feb 2009</td>
<td>Electrical Networks, Connection and Conditioning</td>
<td>Edinburgh</td>
</tr>
<tr>
<td>Jun 2009</td>
<td>Tidal Hydrodynamics</td>
<td>Belfast</td>
</tr>
<tr>
<td>Sep 2009</td>
<td>Electrical Machines</td>
<td>Edinburgh</td>
</tr>
<tr>
<td>Winter</td>
<td>Career development, writing for publication</td>
<td>Lancaster</td>
</tr>
<tr>
<td>Spring</td>
<td>Moorings and Fixings</td>
<td>Edinburgh</td>
</tr>
<tr>
<td>Summer</td>
<td>Environmental consequences</td>
<td>Belfast</td>
</tr>
<tr>
<td>Winter</td>
<td>Commercialisation and Entrepreneurship</td>
<td>TBC</td>
</tr>
<tr>
<td>Etc</td>
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</tbody>
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Internationalisation and Knowledge Exchange

IES industry and policy engagement has grown world-wide to include high-level and detailed partnership in 15 countries
Internationalisation and Knowledge Exchange

R&D Framework Agreement with EdF Energy in Marine Energy and Network Integration.

R&D MOUs with: Dalhousie Canada, Florida Atlantic and UMASS USA, New Zealand and Dalian China

Engaged with Federal, State and Governmental initiatives in many of these countries – CMER, MREC

Staff project managing British and IEC standards

Opening and ongoing discussions: Chile, South Africa, Taiwan and Korea
Internationalisation and Knowledge Exchange

Our UKERC and International Road Mapping identified research priorities to establish the industry as:

- Test facilities
- Moorings and Foundations
- Resource modelling
- Device modelling
- PTO and control
- Installation and O&M
- Survivability
- Electrical Power infrastructure and technology
- Economics & Policy
- Standards & Life cycle analysis

There is great scope for collaboration to address these challenges